BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system listed below. All American National Standard Institute (ANSI) Hazard Class 3b and 4 laser systems must be documented, reviewed, and approved through use of this form. Each system must be reviewed annually.

System description: LAMBDA PHYSIK LPF™ 202 LASER
Location: 937 Tunnel

LINE MANAGEMENT RESPONSIBILITIES

The Owner/Operator for this laser is listed below. The Owner/Operator is the Line Manager of the system and must ensure that work with this laser conforms to the guidance outlined in this form.

Owner/Operator:		
Name: I. Yamane	*Signature:* ***Signature on File***	*Date:*

AUTHORIZATION

Work with all ANSI Class 3b and 4 laser systems must be planned and documented with this form. Laser system operators must understand and conform to the guidelines contained in this document. This form must be completed, reviewed, and approved before laser operations begin. The following signatures are required.

C. Weilandics	***Signature on File***	
BNL LSO printed name	*Signature*	*Date*
A. Etkin	***Signature on File***	
Department ES&H Approval printed name	*Signature*	*Date*

APPLICABLE LASER OPERATIONS
☒Operation ☒Maintenance ☐ Service ☐ Specific Operation ☐ Fiber Optics

LASER SYSTEM HAZARD ANALYSIS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system. The analysis includes both laser (light) and non-laser hazards. A Nominal Hazard Zone (NHZ) analysis must be completed to aid in the identification of appropriate controls.

LASER SYSTEM CHARACTERISTICS					
Laser Type *(Argon, CO_2, etc.)*	Wavelengths	ANSI Class	Maximum Power or Energy/Pulse	Pulse Length	Repetition Rate
Excimer	157 nm, 620 nm & 780 nm	IV	50mJ/Pulse	20 ns	20Hz

☐ **Cryogen Use**
NONE

☒ **Chemicals & Compressed Gasses**

The LPF™ 202 excimer laser operates on a gas mixture of 5% F_2 balance He. The laser gas mixture is contained in the laser cavity and is filled by an 8 L volume cylinder at 34 bar. Due to the low TLV of F_2 ventilation system is necessary to vent to outside the tunnel any accidental release of Fluorine. The gas system schematic is shown in figure 1. The F2 gas mixture cylinder is contained in a gas cabinet connected to a power vent that will vent any F2 in the event a fitting leaks. The laser exhaust is also connected to the vent line. The exhaust gas is scrubbed of fluorine prior to discharge so that in normal operation no Fluorine will be vented through this line. Fluorine would be vented only by an accidental leak in the gas supply system or laser volume. To prevent exposure to personnel two Fluorine monitors are used. One F2 monitors the gas inside the laser cabinet. The second F2 monitor monitors for the presence of F2 in the tunnel. If either monitor detects Fluorine, a warning alarm and strobe will alert personnel to clear the tunnel and a solenoid valve will close to shut off the F2 gas supply line.

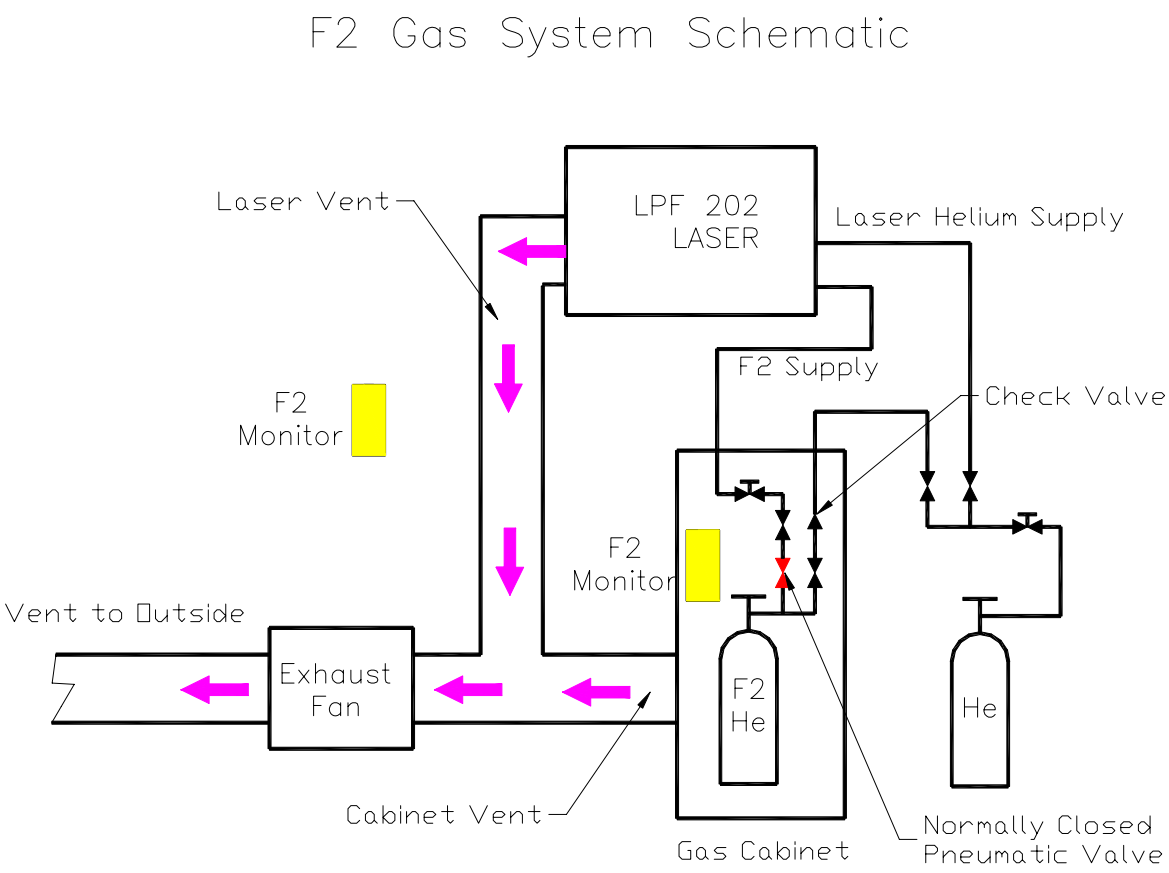

Figure 1.

☒ **Electrical Hazards**

The power supply for the thyratron is a Lambda Physik supplied item. The electrical specifications of the power supply are:

Input Voltage: 208 VAC ±10% 3 phase

Frequency: 60 Hz

Apparent load: 9 KVA

Fuse rating per phase: 24 A

The electrical power connection to the laser will be completed in accordance with the National Electric Code (NEC). Any work on the laser electrical system will be conducted following all applicable BNL electrical safety requirements.
The LPF™ laser is designed with various electrical safety features that are outlined in section 3.2.3.2 of the User Manual LPF™ 200.

☐ **Other Special Equipment**

Laser System Configuration: Describe the system controls *(keys, switch panels, computer controls),* beam path, and optics *(provide a functional/block diagram for complicated beam paths)*.

The laser is a commercial (Lamda Physik) excimer laser operating at 50 mJ/pulse and 20Hz. The output characteristics of the laser are as follows:

Wavelength:	157 nm
Max. Average Power:	1 W
Repetition Rate:	20 Hz
Spot Size:	20 mm x 8 mm
Divergence:	Vertical 1.7 mrad, Horizontal .6 mrad
Pulse Duration:	20 ns

The laser is position on a stand in Tunnel 937. The laser beam path is completely enclosed by metal vacuum pipe and chambers. A glass viewport is above the mirror that allows for alignment. During initial alignment a HeNe laser is used and a glass viewport is put in place of the laser beam monitor. The excimer laser power is monitored by use of the laser beam monitor. The excimer laser position is verified by using a CCD camera to observe the beam spot on a quartz disc that is put into the interaction region remotely by a linear feedthru. A schematic of the laser beam transport is shown in figure 2.

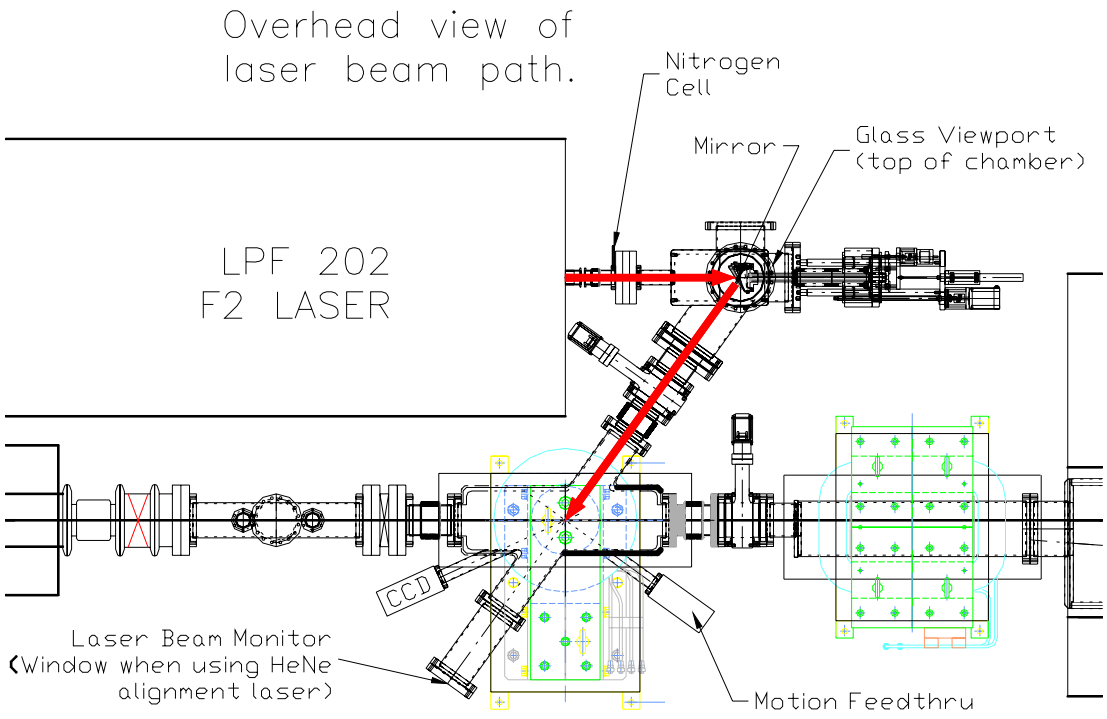

Figure 2.

DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

Recognition, evaluation, and control of laser hazards are governed by the following documents.

American National Standards Institute (ANSI) Standard for Safe Use of Lasers;
(ANSI Z136.1-2000)

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard: 1.5.3 INTERLOCK SAFETY FOR PROTECTION OF PERSONNEL

ENGINEERING CONTROLS

☒ Beam Enclosures	☒ Protective Housing Interlocks	☐ Other
☒ Beam Stop or Attenuator	☒ Key Controls	
☒ Activation Warning System	☐ Other Interlocks	
☒ Ventilation	☒ Emission Delay	

Describe each of the controls in the space provided below this text. Interlocks and alarm systems must have a design review and must be operationally tested every six months. Controls incorporated by the laser manufacturer may be referenced in the manuals for these devices. **If any of the controls utilized in this installation requires a design review, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

Beam Enclosures: During Operation, Maintenance and Service the laser beam path is completely enclosed by vacuum chambers of the system. A glass viewport above the mirror allows for visual adjustments of the mirror. When a HeNe laser is used for alignment a window will be affixed where the laser beam monitor normally is placed.

Beam Stop or Attenuator: Each beam exit from the laser housing can be closed by a manually operated beam shutter.

Activation Warning System: A red laser ON warning light is located next to the beam exit aperture on the laser housing front panel (Figure 3 page 15 of User Manual LPF 200). The warning light illuminates when the laser is emitting radiation.

Ventilation: The ventilation system is described above in the Chemical & Compressed Gases section.

Protective Housing Interlocks: All service panels on the LPF™ are equipped with interlock switches that shut off the high voltage if a panel is opened during operation.

Key Control: The laser system has a key control needed to make the laser operational. This key will be turned off when the laser is not in use to avoid unintentional laser operation.

ADMINISTRATIVE CONTROLS

☒ Laser Controlled Area ☒ Signs ☒ Labels ☐ Operating Limits

The format and wording of laser signs and labels are mandated by BNL and ANSI standards. Only the standard signs are acceptable. Standard signs are available from the BNL Laser Safety Officer.

All lasers must have a standard label indicating the system's wavelength, power, and ANSI hazard class. Required labels must remain legible and attached. The manufacturer should label commercial systems.

Standard Operating Procedures (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. The BNL Laser Safety Officer must approve SOPs and copies should be available at the laser installation for reference and field verification of stated control measures.

Administrative Controls Description:

Laser Controlled Area: during normal operation the beam is confined to the experimental chamber. If work needs to be done on the system, a laser-controlled area will be designated at or near the entry point to the tunnel.

Signs: normally the beam will be fully confined to the experimental chamber, so signs will not be needed. Designation of the laser-controlled area in the event of an open system will be controlled with appropriate signs.

Labels: labels stating the output of the system lable beam enclosures

CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. Examples include any protective housings, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Entries should also be included to ensure placement of required signs and labels and status of interlock verification. Completed checklists must be posted at the laser location. The checklist does not have to be redone unless there has been a system modification, extended shutdown, or change of operations.

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☐ Eye Wear

Skin Protection: For UV lasers or lasers that may generate incidental UV in excess of maximum permissible exposure (MPE) describe the nature of the hazard and the steps that will be taken to protect against the hazard.

Eye Wear: All laser protective eyewear must be clearly labeled with the optical density and wavelength for which protection is afforded. Eyewear should be stored in a designated sanitary location. Color - coding or other distinctive identification of laser protective eyewear is recommended in multi-laser environments. Eyewear must be routinely checked for cleanliness and lens surface damage.

1. For invisible beams, eye protection against the full beam must be worn at all times unless the beam is fully enclosed.
2. For visible beams, eye protection against the full beam must be worn at all times during gross beam alignment.
3. Where hazardous diffuse reflections are possible, eye protection with an adequate Optical Density for diffuse reflections must be worn within the nominal hazard zone at all times.
4. If you need to operate the laser without wearing eye protection against all wavelengths present, explain the precautions that will be taken to prevent eye injury.

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Define eyewear optical density requirements by calculation or manufacturer reference and list other factors considered for eyewear selection. The BNL Laser Safety Officer will assist with any required calculations.

EYE WEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***
Excimer	157	See comment below§			
	620	4.4 (0.25 sec)	1.7	1.4	
	780	4.6 (10 sec)	1.5	1.2	

§ the 157 nm wavelength is highly attenuated in air; transmission is negligible beyond a few millimeters. As a precaution however standard polycarbonate glasses should be worn as a general precaution.

* Diffuse ODs are calculated assuming a 600 second exposure, a viewing distance of 20 cm, perfect reflectivity, and viewing normal to the surface. The ODs required can decrease for more typical conditions in the laboratory.

**The Nominal Hazard Zone is that zone or distance inside which exists a hazard to the eye from a diffuse reflection (as well as direct or specularly reflected light) for the time specified, in this case, 600 seconds (10 minutes).

***Specified eyewear may not be the only possible option, but represents an approved choice; depending on other laser hazards present in the lab, other eyewear may be acceptable provided the optical densities are equivalent or greater than those required.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density

TRAINING

LASER SAFETY TRAINING

Laser Operators must complete sufficient training to assure that they can identify and control the risks presented by the laser systems they use. Owners/Operators and Qualified Laser Operators must complete the awareness level BNL World Wide Web based training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.,
  - Review of SOPs;
  - Review of working procedures, and other program specific documentation.

All laser safety training must be repeated every two years.